Vickers Hardness Sensitivity Coefficients

ISO 6507-1 defines the Vickers hardness value, HV, as:

$$HV = 0.102 \times \frac{2F \sin\left(\frac{\alpha}{2}\right)}{d^2}$$

where:

F = force (in N)
α = plane angle of the indenter (136°)
d = mean indentation diagonal length (in mm)

Partial derivatives allow the sensitivity coefficients for force, indenter ang indentation diagonal length to be determined:

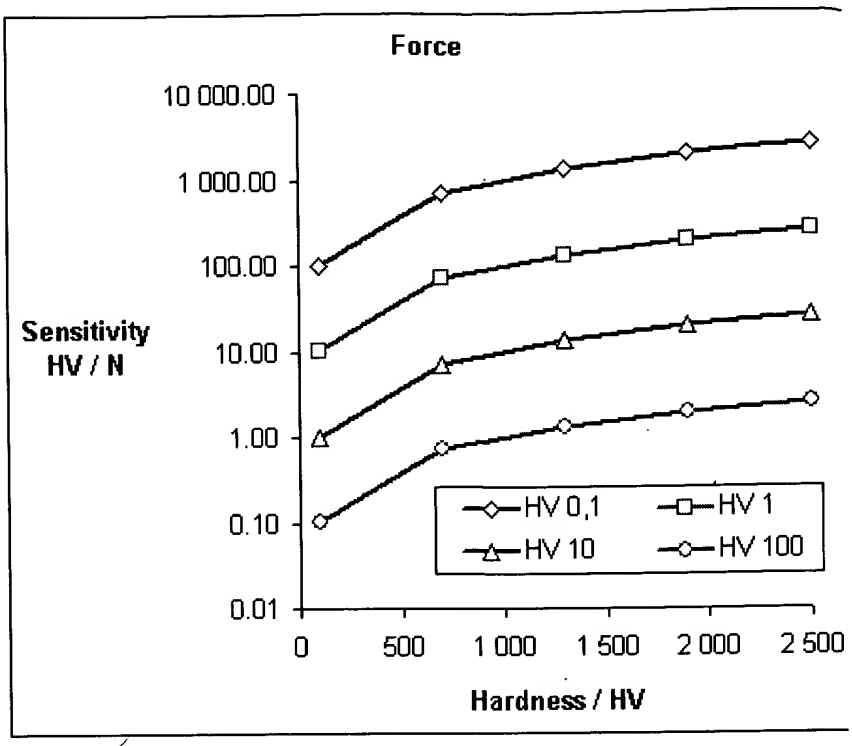
$$\frac{\partial HV}{\partial F} = \frac{HV}{F}$$

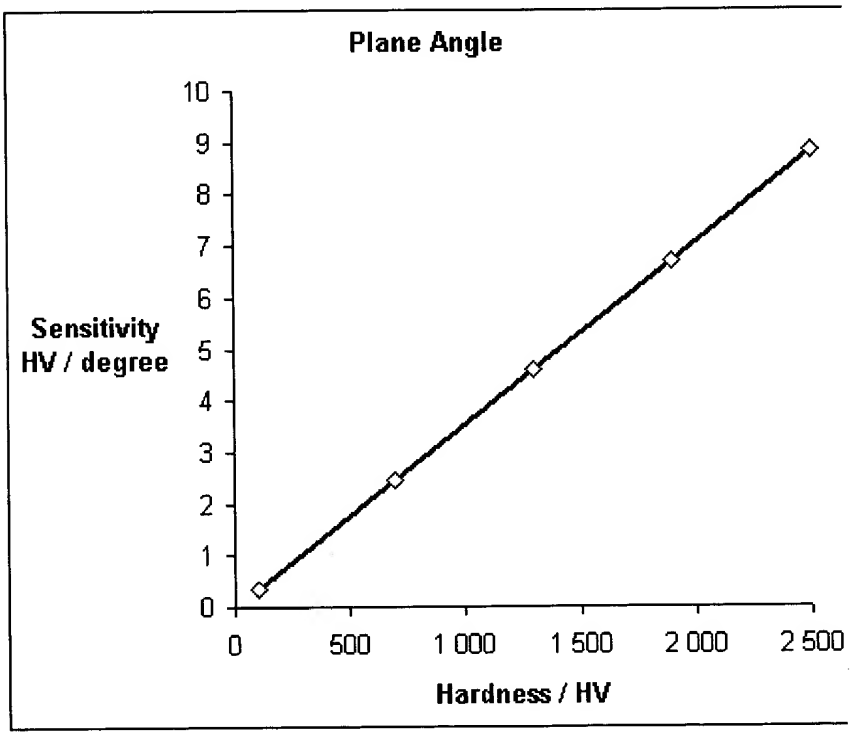
$$\frac{\partial HV}{\partial \alpha} = \frac{HV}{2\tan\left(\frac{\alpha}{2}\right)}$$

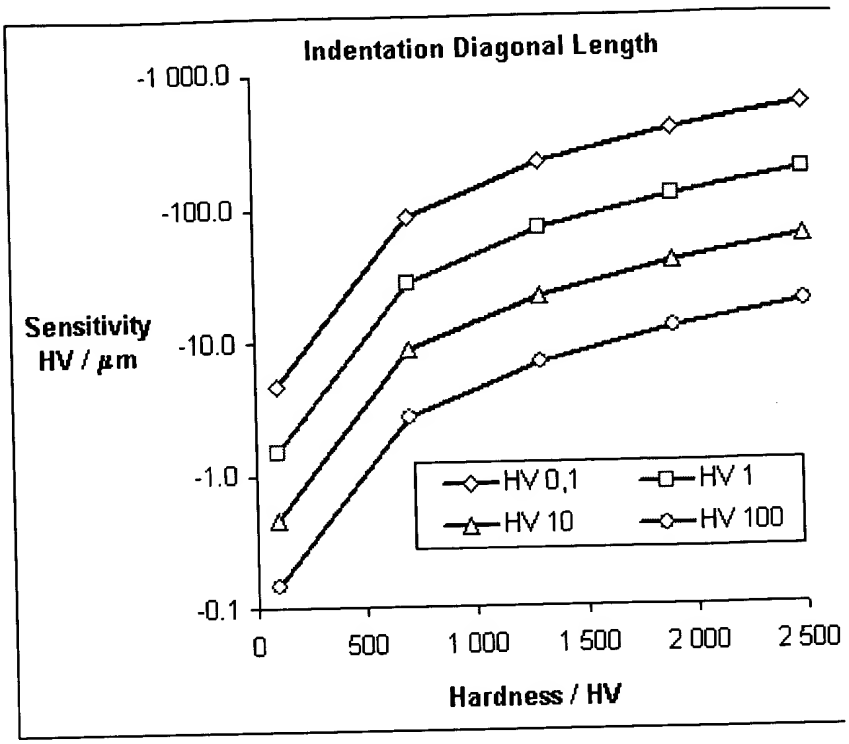
$$\frac{\partial HV}{\partial d} = -2 \times \frac{HV}{d}$$

Graphs showing values of these three sensitivity coefficients against hard given below:

Full Feedback Form







Geometrical considerations allow the sensitivity coefficients for tip radius of line of junction to be approximated:

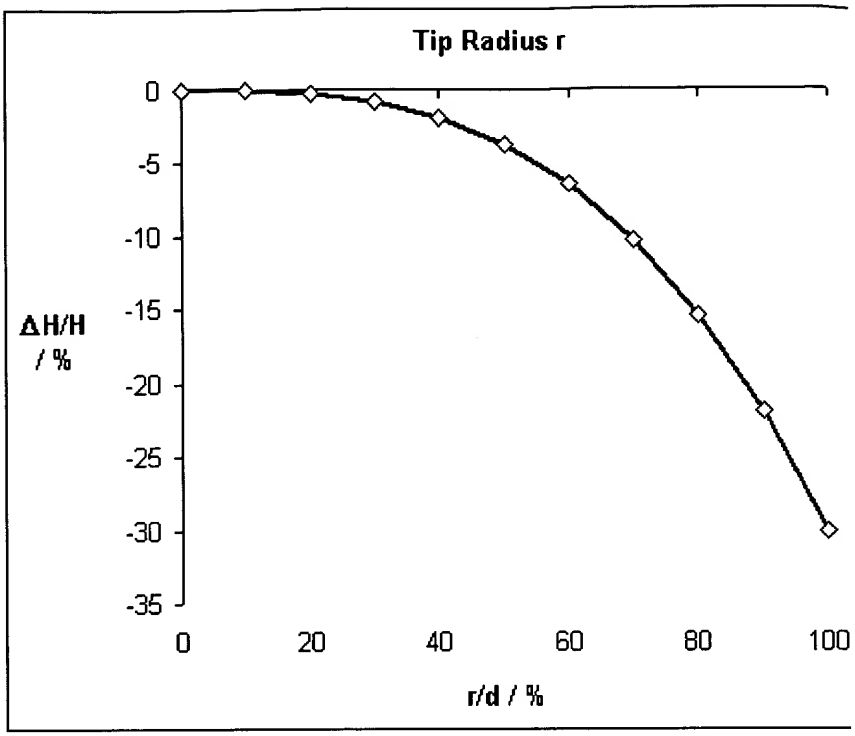
$$\frac{\partial HV}{HV} = -0.3\left(\frac{r}{d}\right)^3$$

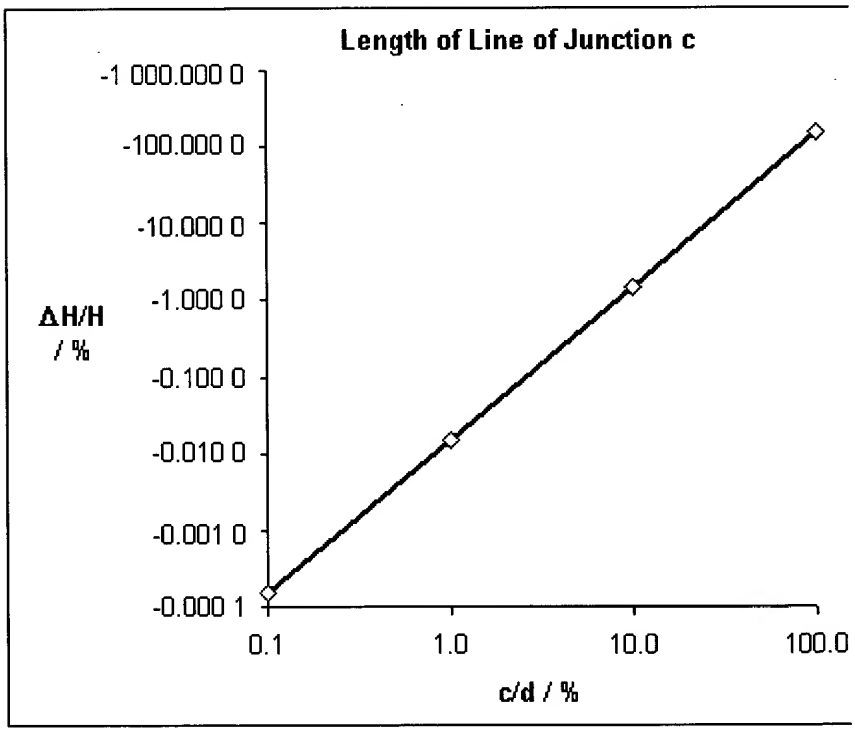
$$\frac{\partial HV}{HV} = -1.5\left(\frac{c}{d}\right)^2$$

where:

r = tip radius (in mm)
c = length of line of junction (in mm)

The assumption made in both cases is that the volume of the indentation the same, for varying values of r and c, as would be the case with an ind perfect geometry. Graphs showing values of these two parameters are gi





Practical experiments were carried out, for the HV 10 and HV 30 ranges, determine the sensitivity coefficients for loading time and test force dural addition, the sensitivities to force value were also determined, to see hov agreed with the theoretical values.

Sensitivity to application time and force duration

ISO 6507-1 specifies that, for forces of 49.03 N (HV 5) and above, "the t
the initial application of the force until the full test force is reached shall r
than 2 s nor greater than 8 s" and that "the duration of the test force sha
to 15 s".

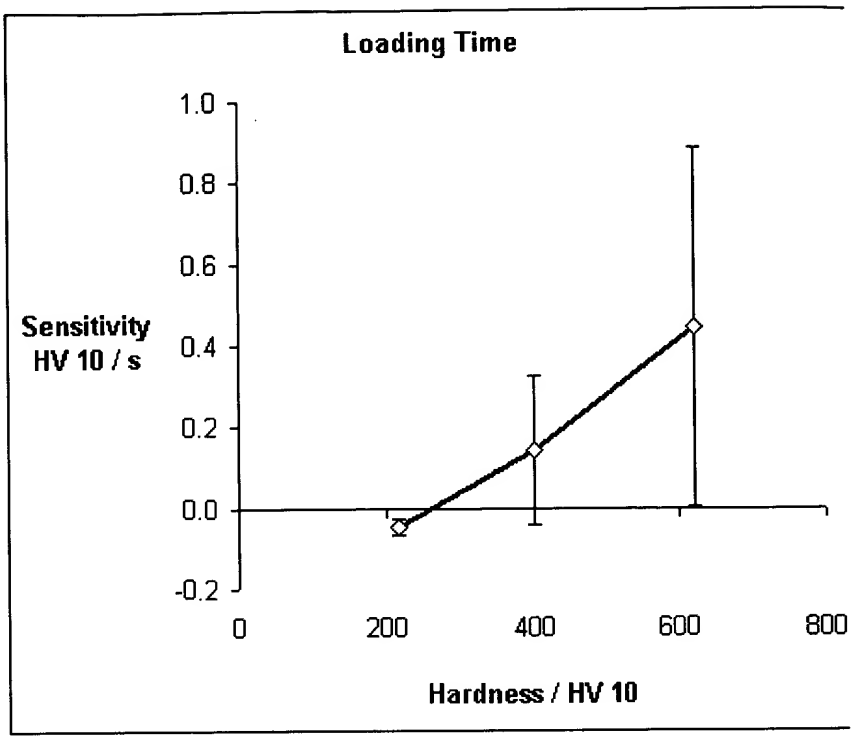
For both ranges, five hardness tests were carried out on each of three blc
different nominal hardnesses, at different values of the input parameter:

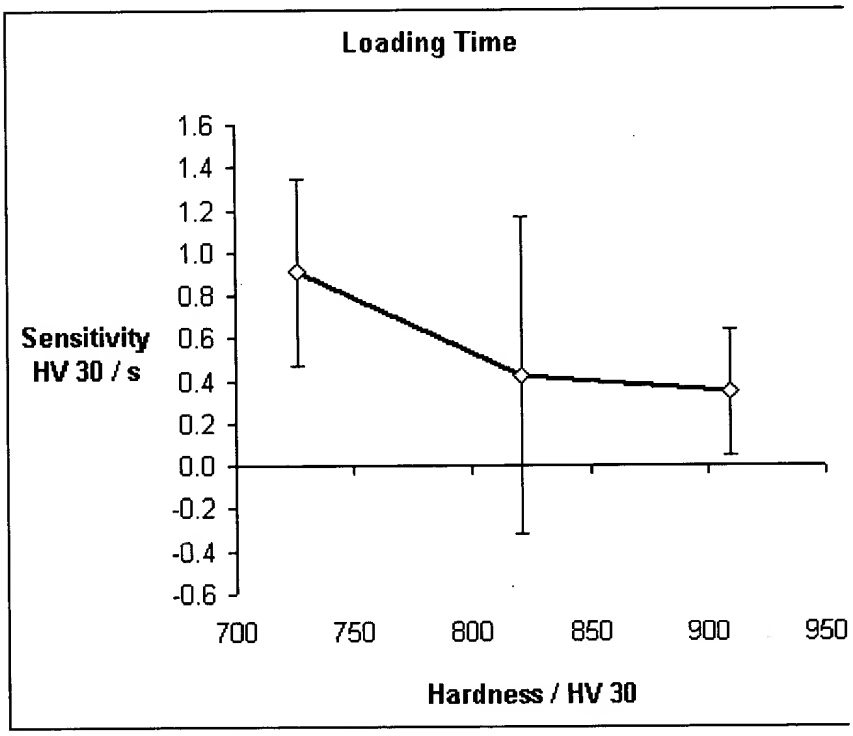
Range	Force	Parameter	Value 1	Value 2	Value 3
HV 10	98.07 N	Application time	2 s	4 s	6 s
		Force duration	10 s	13 s	15 s
HV 30	294.2 N	Application time	2 s	4 s	6 s
		Force duration	10 s	13 s	15 s

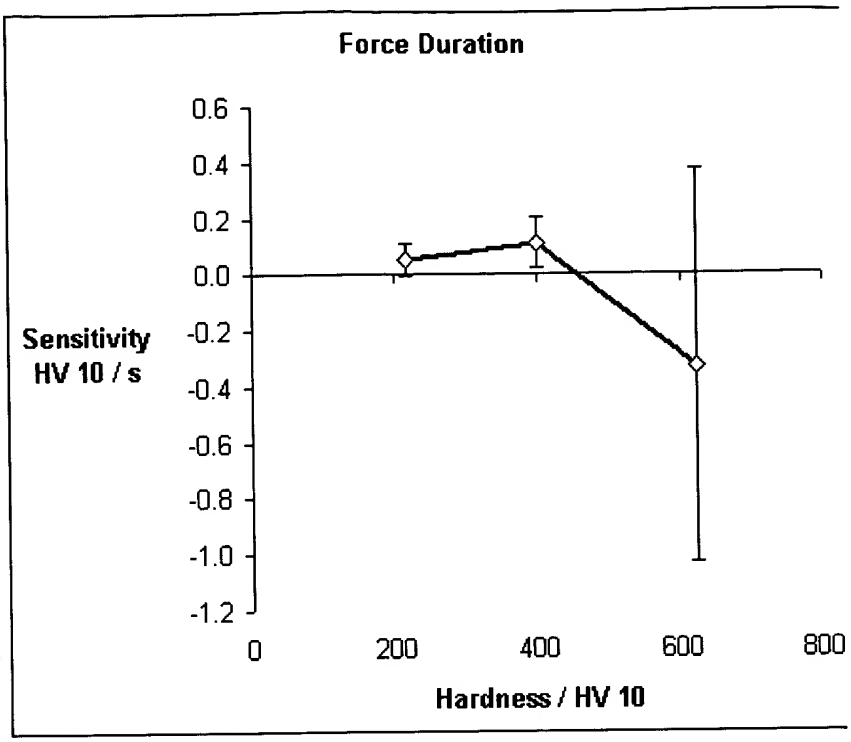
The forces were not applied in a single linear profile, but in two linear sec
80 % of the force in 25 % of the time followed by the final 20 % of the fc
remaining 75 % of the time:

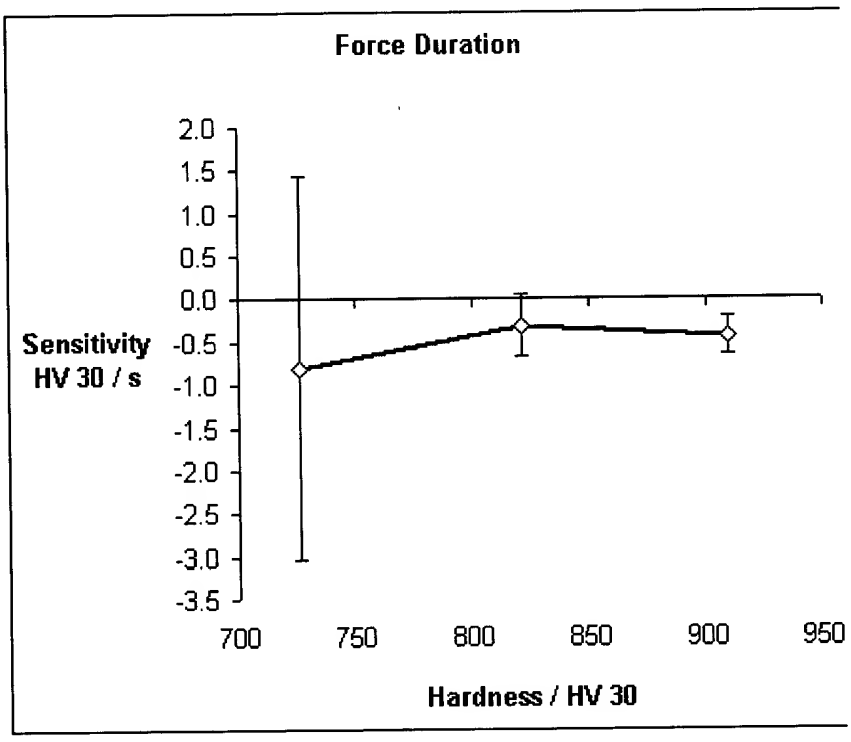
Range	Application time	Part 1			Part 2		
		Force	Time	Rate	Force	Time	
HV 10	2 s	78.46 N	0.5 s	156.9 $N \cdot s^{-1}$	19.61 N	1.5 s	1
	4 s		1.0 s	78.46 $N \cdot s^{-1}$		3.0 s	6
	6 s		1.5 s	52.30 $N \cdot s^{-1}$		4.5 s	4
	8 s		2.0 s	39.23 $N \cdot s^{-1}$		6.0 s	3
HV 30	2 s	235.4 N	0.5 s	470.7 $N \cdot s^{-1}$	58.8 N	1.5 s	3
	4 s		1.0 s	235.4 $N \cdot s^{-1}$		3.0 s	1
	6 s		1.5 s	156.9 $N \cdot s^{-1}$		4.5 s	1
	8 s		2.0 s	117.7 $N \cdot s^{-1}$		6.0 s	9

For each of the three hardness blocks, the mean measured hardness was
against the input parameter (application time or force duration) and a lin
squares fit was applied to the data. The gradient of this line (the sensitivi
hardness to the input parameter) was plotted against hardness for the th
and these values are shown in the following graphs. The error bars relate
linearity of the fit of hardness against input parameter at each of the har
values – each error bar is ±2 × the standard error associated with the es
the gradient (sensitivity coefficient).


Loading Time
Sensitivity HV 10 / s
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0
200
400
600
800
Hardness / HV 10


Loading Time
Sensitivity HV 30 / s
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
700
750
800
850
900
950
Hardness / HV 30





Sensitivity to force value

ISO 6507-2 specifies that, for forces of 1.961 N (HV 0.2) and above, eacl force verification measurements in the machine (made by an ISO 376 Cla proving device) shall agree with the nominal force to within a tolerance o

For both ranges, five hardness tests were carried out on each of three blc

different nominal hardnesses, at different values of force:

Range	Force		
	Run 1	Run 2	Run 3
HV 10	96.60 N	98.07 N	99.54 N
HV 30	287.79 N	294.20 N	298.61 N

For each of the three hardness blocks, the mean measured hardness (cal using the nominal force) was plotted against applied force and a linear le squares fit was applied to the data. The gradient of this line (the sensitivi hardness to force) was plotted against hardness for the three blocks, and values are shown in the following graphs. The error bars relate to the line the fit of hardness against force at each of the hardness values – each er ±2 × the standard error associated with the estimate of the gradient (se coefficient). The red lines are plots of the sensitivity coefficients obtained taking a partial derivative of the hardness equation – they are plotted as values, rather than positive ones (as the equation suggests), because the values are calculated from the nominal force and the actual indentations, than from the actual force and the indentation size at nominal force.